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IMPROVEMENTS AND MODIFICATIONS TO THE NASA MICROWAVE SIGNATURE ACQUISITION SYSTEM

Final Report

By

B. R. Jean
R. W. Newton
G. L. Warren
B. V. Clark
J. L. Zajicek

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TEXAS A&M UNIVERSITY
REMOTE SENSING CENTER
COLLEGE STATION, TEXAS

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INTRODUCTION

Project Description

The Remote Sensing Center of Texas A&M University (TAMU) has completed a sensor analysis, modification, and construction project for the National Aeronautics and Space Administration, Johnson Space Center (NASA/JSC). The project was divided into two phases of activity. The objectives of the first phase were to make the necessary improvements and modifications to the Microwave Signature Acquisition System (MSAS) that would enable it to perform properly at the original L- and X-band frequencies and to generate preliminary design and interface specifications for the incorporation of a C-band channel. The results of the first project phase are documented in "Improvements and Modifications to the NASA Microwave Signature Acquisition System," Interim Report RSC 3308-1 [1].

The objectives of the second phase of activity were to construct and interface a C-band channel to the MSAS, to provide the required software for operating the modified system and for data reduction, and to design and construct a platform facility for transporting and operating the MSAS during field experiments.

The objectives were defined in terms of four major tasks for which TAMU was responsible.

Task A specified the design, construction, and check out of a C-band (4.90 GHz) radiometer to be integrated with the MSAS L- and X-band radiometers and the MSAS control and monitoring subsystem and equipment.

Task B specified that modifications and improvements be made to the MSAS software to permit (a) efficient and automatic operation, (b) accurate recording of antenna temperatures for the L-, X-, and C-bands, and (c) recording of all ancillary data needed for the accurate reduction of radiometric brightness temperatures. Task B also provided for purchasing of an additional 4K (4096) bytes of core memory for the MSAS Rolm 1601 minicomputer.

Task C required that a platform suitable for use in the collection of data from the MSAS radiometers be developed and implemented. The platform was specified to consist of an aerial boom truck, a data van, boom positioning hardware, cabling, and all other equipment required to operate the MSAS and record the resulting data during field experiments. Task C also provided that an antenna positioning system be installed for quickly and accurately positioning the antennas and that an antenna support truss be constructed.

The contract agreement specified that the aerial boom truck and data van be purchased with TAMU funds and that TAMU retain ownership of the vehicles. NASA funds were provided to modify the van and boom trucks. These modifications were to include air conditioning of the data van, installing high capacity

voltage regulators, interior modifications to the van, electrical installations, and all mechanical and electrical modifications to the aerial boom necessary for accurate and efficient operation of the MSAS.

Task D specified that the configuration of the data van, aerial boom truck, C-band radiometer, and the software be documented through complete drawings, circuit diagrams, and other appropriate means. The performance of the complete platform and the C-band radiometer was also to be documented.

Summary of Results

All tasks have been successfully completed and the MSAS is now in a fully operational condition. The software and hardware modifications to the system have greatly simplified the data acquisition procedure and have allowed for more efficient operation of the system and improved data quality.

The sensor capability has been expanded by the addition of a C-band (4.90 GHz) channel to the original L-band (1.41 GHz) and X-band (10.69 GHz) channels. The system platform facility includes a modified Reach-All HD 50-50 aerial boom mounted on a Ford F750 truck chassis; a 7.5' x 16' van mounted on an International Loadstar 1600 chassis which houses the MSAS controller, Rolm 1601 minicomputer, Ampex 7-track tape drive, the automatic antenna positioner microprocessor and display, and operation console; and a trailer mounted 15 KVA Onan gasoline fueled generator.

Scope of the Report

This report provides a user oriented description of the modified and upgraded Microwave Signature Acquisition System.

The present configuration of the sensor system and its operating characteristics are documented and a step-by-step operating procedure provides instructions for mounting the antenna truss assembly, readying the system for data acquisition, and for controlling the system during the data collection sequence. The resulting data products are also identified.

Additional detailed documentation of the software modifications to the MSAS operating system is given in "Microwave Signature Acquisition System Software Operating System and Procedures," RSC 3308-2 [2]. The addition of the C-band radiometer channel and the design and construction of the antenna positioning system are documented in "Microwave Signature Acquisition System, C-band Channel Maintenance Manual," RSC 3308-3 [3] and "Microwave Signature Acquisition System, Antenna Positioner Maintenance Manual," RSC 3308-4 [4], respectively.

SYSTEM DESCRIPTION

The Microwave Signature Acquisition System is a three frequency microwave radiometer system which can provide calibrated brightness temperature measurements over a dynamic range of approximately 0° to 750° Kelvin. The specifications of the radiometer system are summarized in Table 1. The measurement polarization may be continuously varied from vertical to horizontal for any look angle from nadir to zenith (0° to 180°).

There is a separate antenna and RF receiving subsystem for each of the three frequency bands. The L-band antenna is a

TABLE 1.0

Specifications of the Radiometer System

	L-Band	C-Band	X-Band
Center Frequency (GHz)	1.413	4.900	10.625
Bandwidth (MHz)	30	200	200
Sensitivity (°K)	0.5	0.2	0.8
Antenna Beamwidth (3 dB)	20°	10°	6°
Dynamic Range (°K)	0 - 350, Low Range 250 - 750, High Range		

64 element rectangular phased array. The C- and X-band antennas are parabolic dish reflector antennas with rectangular waveguide feed structures.

The RF receiver electronics for each band are housed in separate temperature stabilized enclosures. The L-band receiver enclosure also contains the IF receiver electronics for all three bands as well as the detection, Y-factor measurement and data multiplexing circuitry. Figure 1 is a photograph of the antenna and radiometer systems as they are mounted on the antenna truss assembly.

Band selection and system status monitoring functions are implemented in the MSAS controller subsystem which is mounted in the data van equipment rack near the operator console. The data acquisition procedure is initiated through a sequence of Teletype input commands to a Rolm 1601 minicomputer. The minicomputer interfaces to the MSAS controller, a 7-track Ampex digital magnetic tape unit, and the antenna positioning system microprocessor. The photograph of Figure 2 shows the equipment rack and operating console as it is installed in the data van.

The antenna positioning system consists of a microprocessor controller, a manual elevation angle and polarization selection control panel, an elevation and polarization display panel, and independent closed loop elevation and polarization control circuits.

The data van, in addition to housing the system control and data collection electronics, provides storage space for the

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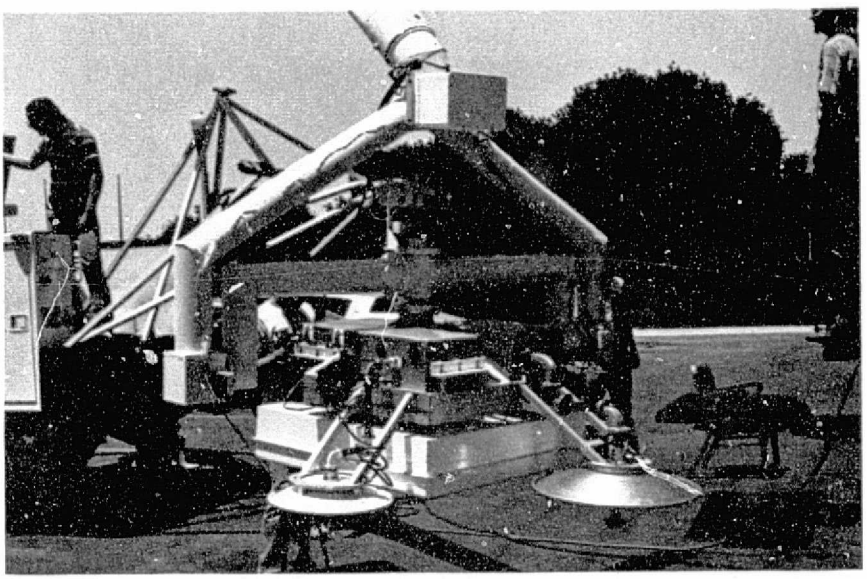

Figure 1. Radiometer and Antenna System

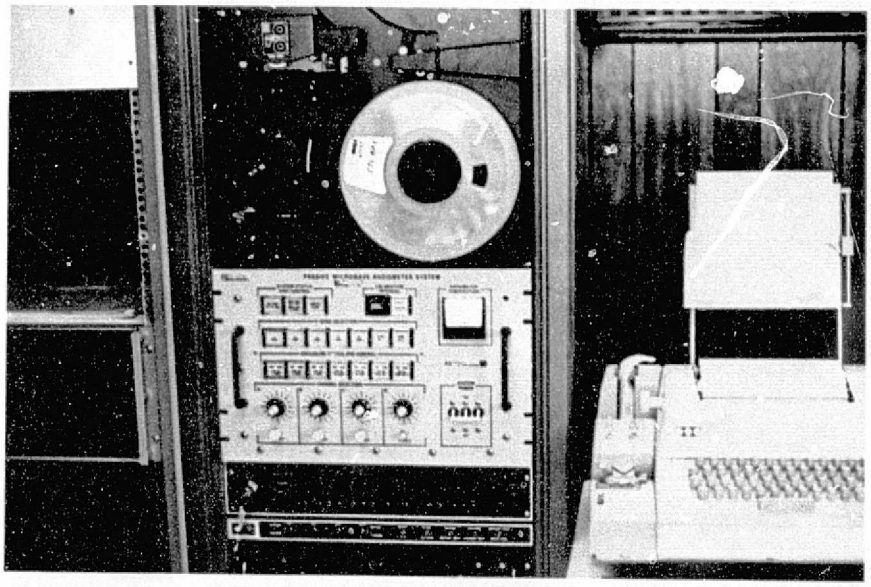

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Figure 2. Operating Console

radiometer and antenna truss assembly during transport and provides sufficient work space and facilities for in-the-field maintenance and repair of the MSAS. The van is air conditioned and well insulated to provide for operator comfort and safety over the extremes of weather conditions which are likely to be encountered during field experiments. The photograph in Figure 3 illustrates the various features of the data van facility.

A hydraulic powered aerial boom assembly, pictured in Figure 4, constitutes the working platform for the MSAS. The boom assembly elevates the antenna and radiometer assembly to a nominal working height of approximately 13.7 meters (45 feet). Detailed instructions for mounting the antenna truss assembly and operating the aerial boom are given in the next section. Following the instructions for operating the aerial boom is a complete operating procedure for the MSAS facility.

AERIAL BOOM OPERATING INSTRUCTIONS

Basic Set-Up Procedures

This section describes the basic procedure for operating the hydraulic powered aerial boom. The location, operation and checking of the hydraulic controls are described and specific safety warnings are given. The operating procedure and precautions to be observed in mounting the antenna truss assembly are also described. A concise checklist for setting up the antenna system follows the more general description of the system operating procedure.

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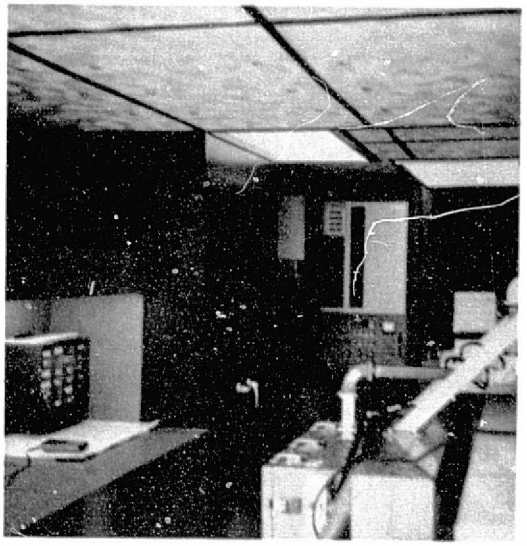

Figure 3. Data Van Interior

Figure 4. Aerial Boom Assembly

Operating the hydraulic boom - Be sure the truck is parked on a firm level terrain. DO NOT attempt to park the truck on terrain which has an overall slope of greater than 5 degrees if boom operation is intended.

Disengage the transmission and set the wheel locks. The wheel locks are an air brake system which is activated by raising the marked lever located to the left of the steering column. The brake pedal is then "pumped" a few times to lock the wheels. NOTE: The wheel locks are to be used only during boom operation. Always release the wheel locks when the boom is not in use. Unnecessary prolonged application of the wheel locks can damage the brake system.

With the clutch depressed, engage the hydraulic system by pulling out the power take-off (PTO) dash control. If the engine lugs, or the hydraulic system is sluggish in operation, the throttle control may be used to increase engine r.p.m. In cold weather, the hydraulic system should be allowed a warm-up period of approximately five minutes before operation.

The outriggers should now be lowered firmly to stabilize the truck platform. The outrigger control valves are located on the cab side of the base of the boom arm assembly as shown in Figure 5. These control valves in left-to-right order are Right Front, Right Rear, Left Rear, and Left Front. To the right of the outrigger control valves is the outrigger/boom selector valve. When in the OUT position, this valve connects the outriggers to the hydraulic power source.

If the truck is not level side-to side, always set

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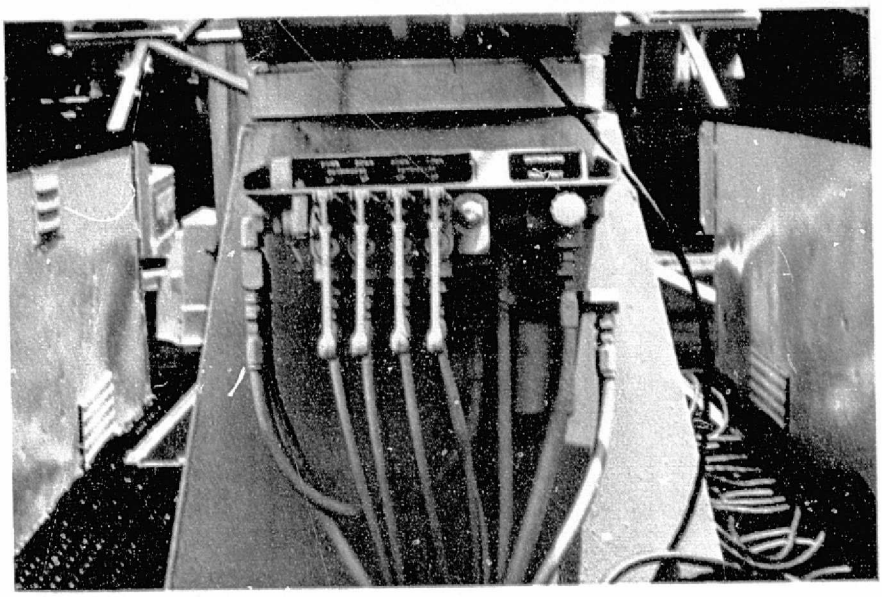

Figure 5. Outrigger Hydraulic Control Values and Outrigger/ Boom Selector Value.

the lower side outriggers first, leveling the chassis as much as possible. DO NOT attempt to raise the wheels clear of the ground; the outriggers were designed to correct for a slope angle of up to 5° only and not to carry the weight of the chassis. Once the truck has been leveled, the upside outriggers may be brought to rest firmly on the ground.

DO NOT attempt to operate the boom unless outriggers are firmly in position. To do so could result in damage to the system or injury to operating personnel.

To check the outrigger holding valves, push in the outrigger/boom selector valve and then pull each outrigger valve to the UP position. If the holding valves are working properly, the outriggers will not move. DO NOT attempt to operate boom system if outriggers are not holding properly. To do so could result in damage to the system or injury to personnel. With the outriggers firmly planted and checked, operation of the boom may begin.

To operate the aerial boom, the outrigger/boom selector valve must be pushed to the IN position. Before attempting to operate the boom, the boom hold down strap shown in Figure 6 must be released. There are two metal hold downs on the boom truss assembly which must also be removed and relocated to form a securing bracket for the elevation axis member. The hold down brackets are pictured in Figure 7 and shown being installed as the elevation member securing bracket in Figure 8. NOTE: Failure to release boom truss from support tie-downs or failure to secure the elevation axis member will result in damage to the system.

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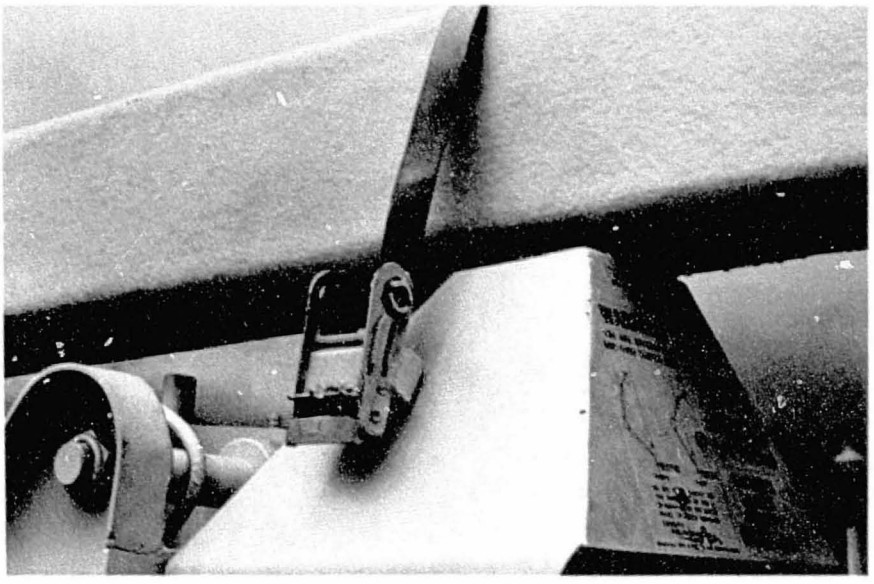

Figure 6. Boom Tie-down

Figure 7. Boom-Truss Hold-down Brackets

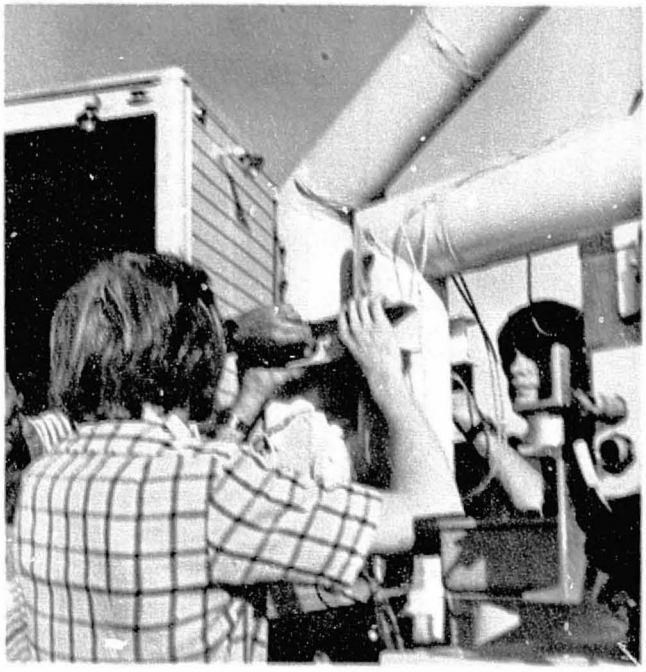

Figure 8. Boom-Truss Hold-downs as Elevation Axis Member Securing Bracket.

Once the boom is free of its tie-downs and the elevation axis member is secured, the boom may be raised from its supports.

The boom control valves are located to the rear of the aerial boom assembly, just above the boom pivot. (See Figure 9.) These control valves in left to right order are Lower Boom Up/Down, Upper Boom Up/Down, and Boom Rotation Clockwise/Counterclockwise. Care must be exercised in operating the boom assembly. Without the load of an antenna truss assembly, the boom tends to respond with quick motions. Always operate the boom control gently and bring boom movements to a smooth stop. DO NOT reverse the controls quickly. To avoid fast or jerky movements, "feathering" of the boom controls is required.

To "feather" a control is to ease the control from one position to another. Most movements of the boom will be done with the boom controls "feathered" to some position less than the full on position. In mounting and unmounting the antenna truss, feathering of the controls is a must. In raising the aerial boom from its supports, ALWAYS raise the upper boom arm first. If the lower boom arm is raised first, the boom truss is pushed down onto its supports, which may result in damage to the system.

To check the boom holding valves, raise the upper boom arm from its rest, making certain that the elevation axis member is secure in the boom truss assembly. Raise the upper boom arm to approximately 45° from the horizontal. Raise the lower boom arm to approximately 45° from the horizontal. The upper boom arm should now be in a horizontal position. With the upper and lower boom arm in the 0° and 45° positions, respectively, pull the

the outrigger/boom selector control to its OUT position. Push the lower boom control lever to the down position. The lower boom arm should not move. Repeat for the upper boom arm. If the aerial boom arms do not retain their 0° and 45° positions during this test, the holding valves are not operating properly and require servicing as directed in the Reach-All manuals. DO NOT attempt to operate the unit if the boom arm valves are not holding. To do so could result in damage to the system or injury to personnel.

There is one other control system needed for the antenna mounting operation, the antenna positioner control box, located above the boom arm control valves just below the cowl. The control box is shown in Figure 9. The antenna positioner controls consists of four switches which are, in order from left-to-right: Elevation Up/Down, Elevation Auto/Manual, Polarization Counter-clockwise/Clockwise, and Polarization Auto/Manual. ALWAYS keep Auto/Manual switches in Manual position during transport and antenna mounting. Failure to do so could result in damage to the system or injury to personnel. Auto control should be activated only after the antennas are ready to be raised to a working position and the Microprocessor is prepared to control the truss assembly.

The Positioner requires a source of electrical power for operation. This power is supplied by the portable generator through a power cable link-up to the van truck. The power cable is stored in the right front storage cabinet of the boom truck

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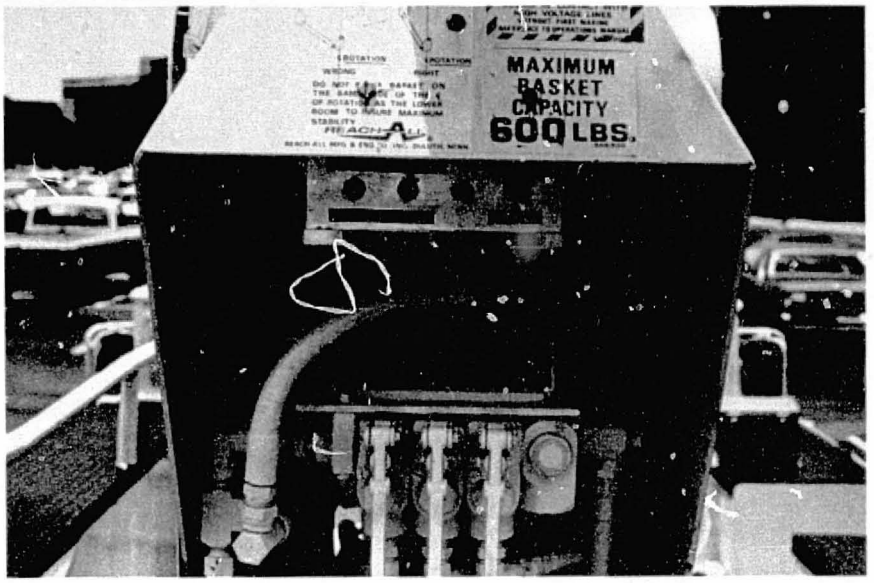

Figure 9. Boom Hydraulic Control Values and Positioner Control Switches

and connects to the patch-box located under the right front corner of the van.

The storage cabinets of the boom truck also contain three data carrying cables in addition to the power cable. Two of these cables convey data to and from the antenna heads and the third provides a data link for the Positioner auto control. These cables connect to a patch-panel on the boom truck and the patch-box of the van.

Antenna Truss Mounting Instructions

The previous section on Basic Set-Up located and described the various hydraulic and electronic controls necessary for the safe operation of the boom truck. In this section, the use of these controls in order to mount the antenna truss to the boom truss is described in a short statement form. The mounting of the antenna truss must be done carefully. The overshoot from a too fast boom arm motion can result in serious damage to the antennas or radiometer enclosures, or injury to personnel. The sequence of photographs in Figures 10-11 illustrate the antenna truss mounting procedure.

Mounting Procedure

1. Be sure trucks are parked properly and wheels are locked. The trucks should be parked on level ground in a back-to-back fashion with a separation of approximately thirteen feet.
2. Prepare boom truck for operation.

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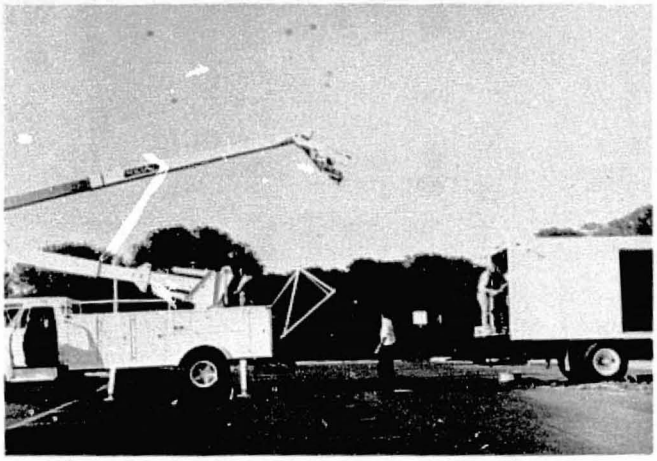

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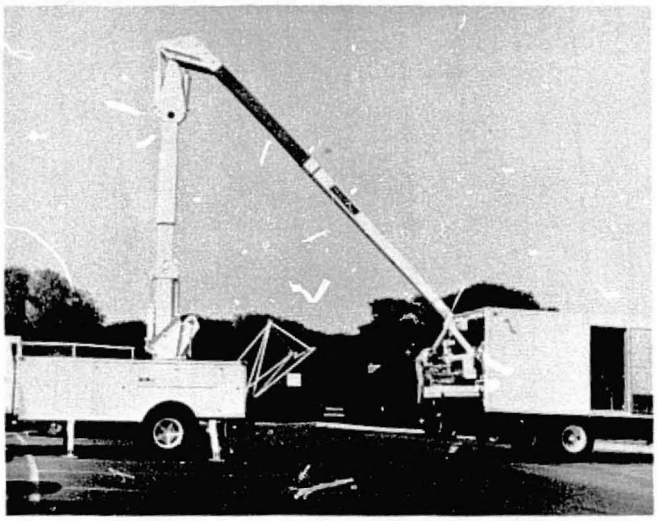
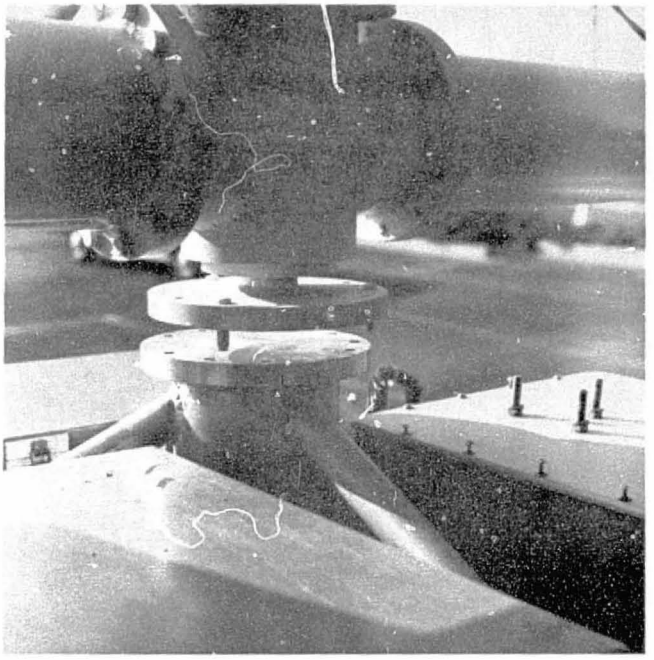


Figure 10. Raising Boom and Positioning For Antenna Mounting

(A)



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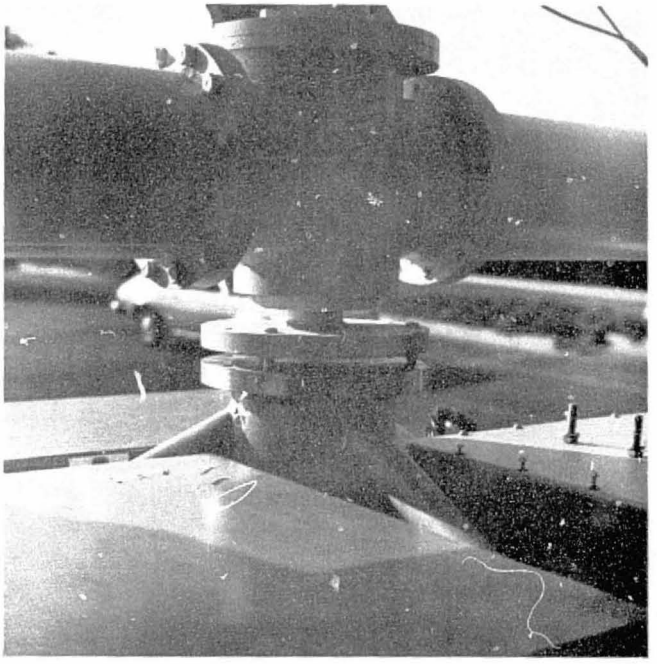

Figure 11. Aligning Mounting Plates

a. Engage PTO.

b. Set outriggers.

c. Release boom tie-downs and secure elevation axis member in boom truss assembly.

d. Check Positioner Auto/Manual switches. These must be set in the manual position.

e. Connect electrical power generator to van and connect boom power cable to van.

f. The three data cables should also be connected at this time.

g. Switch hydraulic power from outrigger to boom.

3. Prepare van truck for antenna loading.

a. Open rear door.

b. Raise "Tommy-Lift".

c. Release antenna truck transport from its tie-downs and position the truss on van tailgate with the mounting plate in the top-horizontal position.

4. Raise boom and position for mounting.

a. Raise upper boom arm clear of transport rests by several feet.

b. Raise lower boom arm clear of transport rests. Remember that moving the lower boom arm moves the upper boom arm. Always watch entire aerial boom assembly when operating.

c. Slowly extend boom arms such that the boom-truss mounting plate arrives at the van

horizontally over the antenna-truss mounting plate.

5. Final Positioning for Mounting. The antenna truss mounting plate has three groups of three holes each along its perimeter. These groups have equal distant spacing as do three alignment pins on the boom truss mounting plate. Located on each side of the pins are threaded holes for the mounting bolts.

   a. Using the Polarization switch of the Positioner control box, rotate the boom mounting plate so that the alignment markers are across from each other. The alignment pins should be over the center hole of the three hole groups. DO NOT activate the Elevation control switch. To do so could shear the shaft extending from the motor gear box or damage the gear box itself.

   b. "Feathering" the upper arm hydraulic controls, gently lower the boom truss until the mounting plates are in contact. DO NOT force the plates together. To do so may result in severe damage to the antennas, especially the L-band array.

   c. With the plates in contact, the six mounting bolts may now be inserted and tightened.

   d. Release the antenna transport tie-downs.

   e. Release the elevation axis member tie-downs.

f. "Feathering" the hydraulic control, slowly raise the antennas clear of the van truck.

6. Moving Boom Truck to "Working" Position.

a. Bring the boom arms back to transport rests. DO NOT "power" the arms into rests, rather let them slip gently into position. Always be aware of the antenna position.

b. Switch the hydraulic power to the outriggers and retract them.

c. Disengage the PTO and release the brake-lock.

d. Keeping aware of boom truck cable linkages to the van, slowly drive the boom truck to the desired "working" position. Boom truck/data van interconnection cables should be carried along by personnel and not dragged by the boom truck. DO NOT drive over cables.

e. Set the brake-lock, engage the PTO, and set the outriggers as described earlier.

f. Raise the aerial boom from its transport rests and fully extend and rotate into the "working" position. DO NOT attempt to rotate the boom unless both boom arms are clear of any obstacle and the outriggers are down.

g. With the boom extended and rotationally positioned and the Antenna Positioner controller ready to take over, the Positioner switches may now be set to Auto.

h. The boom truck engine may now be shut down.

i. If the field is level the brake-lock may be released. If not, leave the brake-lock on until the truck is to be moved to another position.

MSAS OPERATING PROCEDURE

Introduction

The Microwave Signature Acquisition System (MSAS) is a very complex system. However, great care has been taken to design all hardware and software systems for ease of operation. Nonetheless, the system is not foolproof and misuse may result in damage to the system and/or personal injury to its operators. The procedures given in this section will result in the most efficient and safest operation for both the system and its operators.

Power Up Sequence

The system receives power from a 15 KVA Onan generator. Some of the pertinent specifications of the generator are given below.

Generator Output Voltage	240 Volts
Output Current	62.5 Amps
Frequency	60 Hz
*Fuel Consumption	≈ 1 gal./hr.
Fuel Capacity	50 gal.

* Although the fuel consumption has been found to be about one gallon per hour, it is recommended that the generator fuel tank be refilled every 35-40 hours of operation.

Other specifications and information are given in the Onan manual located in the control panel door. The lubrication and maintenance schedules in this manual should be followed. The electrical system is shown schematically in Figure 12.

Connecting the Generator - Before starting the generator, the power cable must be connected to the van. The receptacle for the cable is located on the driver's side of the data truck underneath the front part of the van. The jack for the remote start cable, which is tied to the power cable, is behind the power cable connector. When these two cables have been connected the generator is ready to be started.

Starting the Generator - The generator can be started from either the control panel on the generator or by a switch inside the data van. It is recommended, however, that it be initially started from the control panel so that the engine gauges (oil pressure and ammeter) and the generator output voltage meter may be monitored. The generator control panel is shown in Figure 13. To start the generator, simply move the three position start switch from the middle position to the top position. When the engine starts, the starter will disengage automatically. When the engine comes up to speed, and the voltmeter reads 240 volts, turn on the 70 amp breaker if it is not already on.

To start the generator from inside the van, the three position start switch on the generator control panel must be in the bottom position. The starter will engage when the remote start switch located on the angle position panel is moved to its up position. Pushing the remote switch back down will stop the

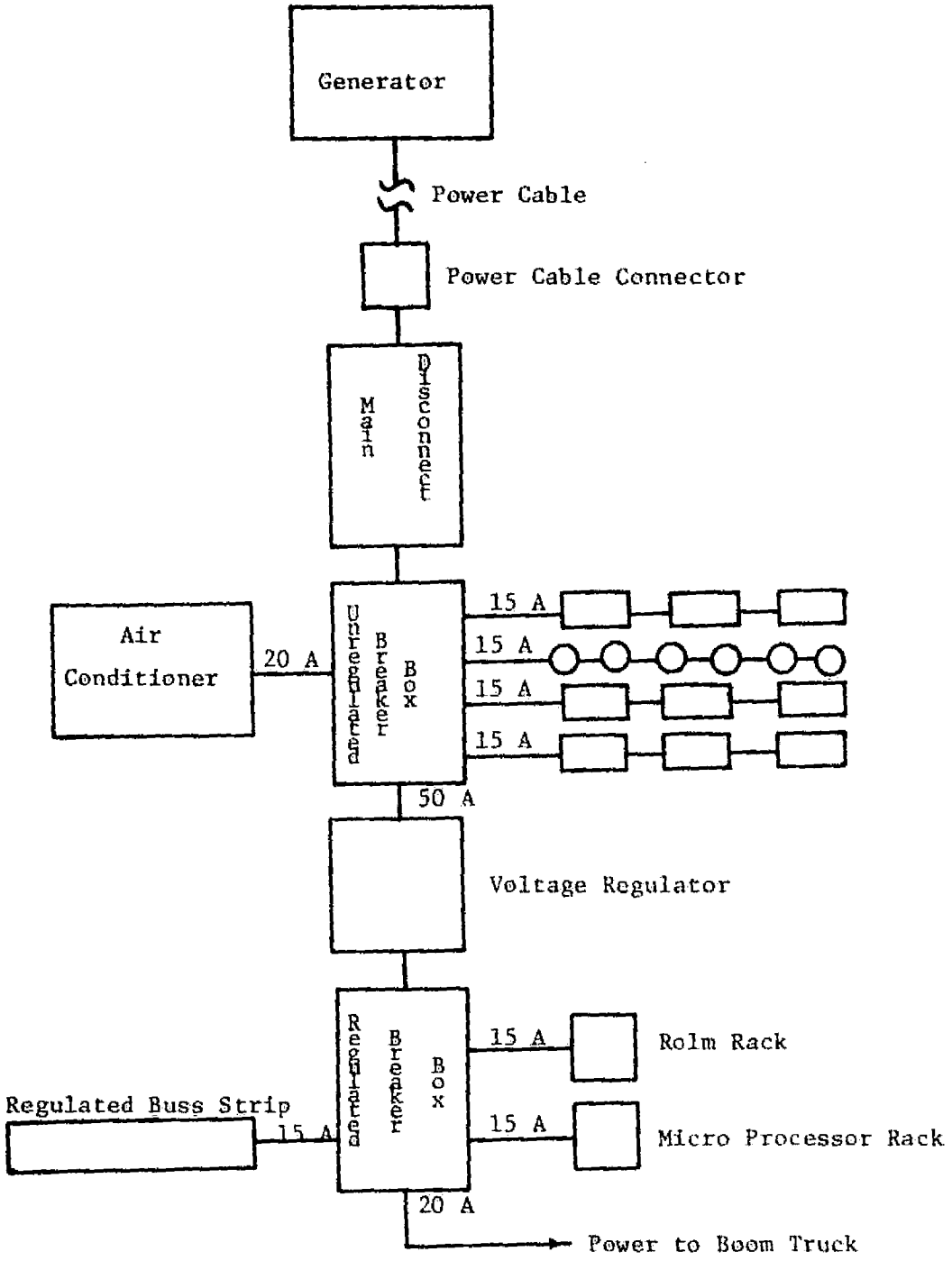

Figure 12. Data Van Electrical System

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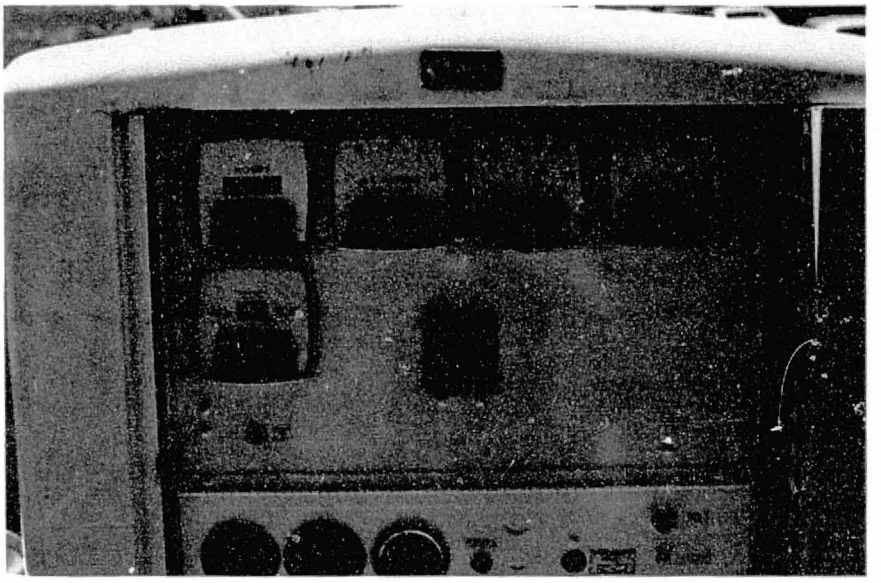

Figure 13. Generator Control Panel

engine. Note: If starting the generator with the 70 amp breaker on, make sure the main disconnect switch in the van is off. The generator will not start under load.

Unregulated Power and Air Conditioner Precautions - Once the generator is started and the 70 amp breaker is on, move the main disconnect switch to the ON position. Power is now available to the lights, wall plugs, air conditioner and voltage regulator. WARNING: The air conditioner has been shown to cause surge currents in excess of 80 amps and has caused the generator to die. In order to prevent this problem the following steps should be taken:

1. Be sure air conditioner is off before turning on main disconnect.
2. Turn the compressor knob (Temp. Control) fully counterclockwise.
3. Set fan control to desired speed (Hi, Med, Low). Do not use the gold "Power Saver Settings" for the fan.
4. After the fan is on, rotate compressor knob to desired position. When the compressor comes on, the generator will strain and the lights will dim, but this should not affect the operation of the rest of the system.

NOTE: The gold "Power Saver Settings" on the fan control (Cooling Control) cause the fan to go on and off when the compressor goes on and off. If the compressor and the fan come

on at the same time the generator may die. Therefore use only the white fan settings.

If the generator does die, the starter will automatically re-engage and try to restart it. Since the generator will not start under load, immediate action is required by the operator. The operator may do one of two things to relieve this condition. If the generator was running with the remote start switch activated, the switch may be pushed to the stop position. This will disengage the starter. The other alternative is to turn the main disconnect switch off. This will remove all load from the generator and it will restart. Before turning the main disconnect switch back on, the air conditioner, MSAS controller, and voltage regulator should be turned off. The main disconnect may be turned on and the normal power up sequence followed.

Regulated Power - Power for the MSAS controller and Rolm Computer rack, the microprocessor rack, the buss strip on the work bench, and the outlets on the boom truck come from the "Stabline" voltage regulator. To turn on the regulator, simply turn on the circuit breaker on its front panel. The voltmeter on the front panel should indicate 115 volts. The microprocessor and angle position display will come on with the regulator. Once the regulator is on, power is available to all of the MSAS components and the power up sequence is complete.

System Status Lights and Alarms

The switch on the front panel of the controller controls the Rolm Computer and the Teletype. Turn the switch on and select

a radiometer band (L, C, or X). When the controller comes on, the teletype will start typing, fans will start, and lights will flash. After a few seconds, the system should settle down to the following state:

1. Alarm (ALM) on L, C, and X bands.
2. "Monitor Alarm" light will be on.
3. "Heater On" lights will be on for the L, C, and X bands.
4. "Meas. Rng. 0-300K" should be on. Pushing this button will cause "Meas. Rng. 200-750K" light to come on. Either measurement range may be selected. The 0-300K range is usually used.
5. In the calibration interval section, the "Computer" light should be on. If the "Manual" light is on, push the button and "Computer" should come on.
6. The Radiometer Temperature meter should indicate about 75% of full scale after the calibration cycle is completed. The calibration cycle lasts 32 seconds and is initiated by: a) pushing manual override, b) selecting a band or changing bands, or c) answering "Y" to computer query of "START?" (See Data Acquisition.)
7. The Radiometer Temperature out of Range (Rad Temp out of Rng) light will be on if a band (L, C, or X) has not been selected. Selecting a band should make it go out.

The Alarms on L, C, and X bands indicate that the radiometer heads are not up to operating temperature. They have internal heaters and fans to keep the enclosure at a preset, constant temperature. When the enclosure reaches that temperature, the alarm light for that respective band will go out. The alarm lights will not go out at exactly the same time, but should all go out within a few minutes of each other. When all three alarm lights go out, the "Monitor Alarm" light should also go out. The monitor light comes on anytime there is an alarm condition in any one of the three heads. The ready lights (RDY) are activated by an internal timer and will not come on until 34 minutes after the system has been turned on even though the alarm lights go off before that.

NOTE: Occasionally, the C band comes on in the ready state. If this occurs, the C band timer should be reset. To reset the timer, push the C band RDY/ALM button. The ready light and the "Heater on C Band" light will go out. Pushing the button again will cause the "Heater on C Band" and the "ALM" lights to come back on, indicating the timer has been reset.

These initial alarms are normal and should occur when the system is turned on. Once they go off and the ready lights come on, there should be no more alarms.

Subsequent alarms - If a subsequent alarm does occur, something is wrong with the system. A subsequent alarm will require shutting down the system and correcting the problem according to the Maintenance Manual.

Antenna Positioning

The antennas can be positioned in one of two ways, manually with thumbwheel switches, or automatically through the teletype. Either method requires that the microprocessor be on and its program running. The microprocessor's program is stored in ROM's so that it does not have to be reprogrammed each time the system is powered up. To start the program push RESET and then START on the processors's front panel. The program is now running and the antennas may now be positioned.

Manual Positioning Procedure

1. Set positioner in manual mode by pushing Manual/ Automatic switch to Manual position.
2. Enter desired elevation and/or polarization angles on the thumbwheel switches. Polarization will be 0° for horizontal and 90° for vertical.
3. At this time either the elevation or polarization data may be sent to the boom. Set the Elevation/ Polarization switch to the desired position and push the ENTER switch up. The antennas will begin to move and the angle information from the boom will be sent back to the LED displays. If both angles are to be sent, it is not necessary to wait for the antennas to stop to send the second angle. Each angle is stored by the positioning system on the boom and both can be processed simultaneously.

4. When LED displays agree with thumbwheel switches, the antennas are positioned correctly.

Automatic Positioning Procedure

1. Set positioner into automatic operation with the Manual/Automatic switch.
2. When the "Angle" and "Polarization" are typed in by the operator during the data acquisition sequence (see Data Acquisition) the angles are sent to the boom and the antennas positioned accordingly. In this mode the thumbwheel switches have no effect. However, the correct angle data will still be displayed by the LED displays.
3. Before starting the program (before answering "Y" to computer query of "START?") make sure the LED displays agree with the angles entered on the teletype. NOTE: Do not confuse this manual/automatic operation with the manual positioning box on the boom truck. When the manual positioning box is in the manual mode, the antennas cannot be positioned from inside the data van.

Data Acquisition (Also refer to [2].)

Powering-Up the System - System turn-on and turn-off should be made with the Tape Unit power switch off and with the Teletype power ON. Further, the software system should always be brought back to the System Monitor (SYSMO) module and the

Front Panel key switch turned to LOCK for power turn-off. The purpose of this procedure is to insure proper software restarts when the power returns to the CPU.

Reloading Core Memory - If memory has become modified to the extent that the system no longer functions properly, the contents may be restored by using the STAND-ALONE loader which starts at location 17237_8. The procedure is as follows:

1. System power - ON
2. Teletype Unit power - ON (LINE)
3. Tape Unit power - ON
4. Mount Program Magnetic Tape and position to Beginning of Tape.
5. Select Tape Unit - ON LINE
6. Set Front Panel Data Switches to 017237_8.
7. Select RESET then START on Front Panel. At this point the S/A LOADER should read the contents of the magnetic tape into core, restoring the program to its proper configuration. The tape read-in takes approximately 3 minutes to complete, at which time the message "LOADED" will be printed on the teletype unit.
8. Select 310_8 on the Front Panel Data switches.
9. Select RESET then START. The "SYSMO" message should print on the teletype, indicating that the system is operating in the SYSTEM MONITOR module and awaiting operator commands.

If during the loading procedure the magnetic tape fails to read in properly it may be because the STAND-ALONE Loader had been altered. To correct this the Loader itself must be reloaded. The S/A Loader object code is stored on punched paper tape and may be loaded using the procedure detailed in Section III of reference [2].

Operating the SYSTEM MONITOR Module - After a correct power-on procedure is executed the software will be operating in the SYSTEM MONITOR module, as evidenced by the teletype message "SYSMO." This routine is primarily a switching and error processing module. Its function is to interpret Operator commands and transfer control to any service module that is requested by the Operator. It also provides a recovery location (or module) for a large group of error conditions, mostly associated with the magnetic tape unit.

The current SYSTEM MONITOR configuration has a repertoire of six commands, as illustrated in Figure 14. Any SYSTEM MONITOR command must be preceded with the "@" key. Any erroneous command string entered will result in the teletype message "*CMD ERR*". The software is designed so that the command decoder is invoked by a teletype interrupt. Any interrupt received by the module that is not from the teletype or a power failure will cause a "FALSE INTERRUPT" message to be displayed on the teletype. A power failure, usually associated with power turn-off will result in orderly software termination and subsequent restart only if the front panel key is in the LOCK position.

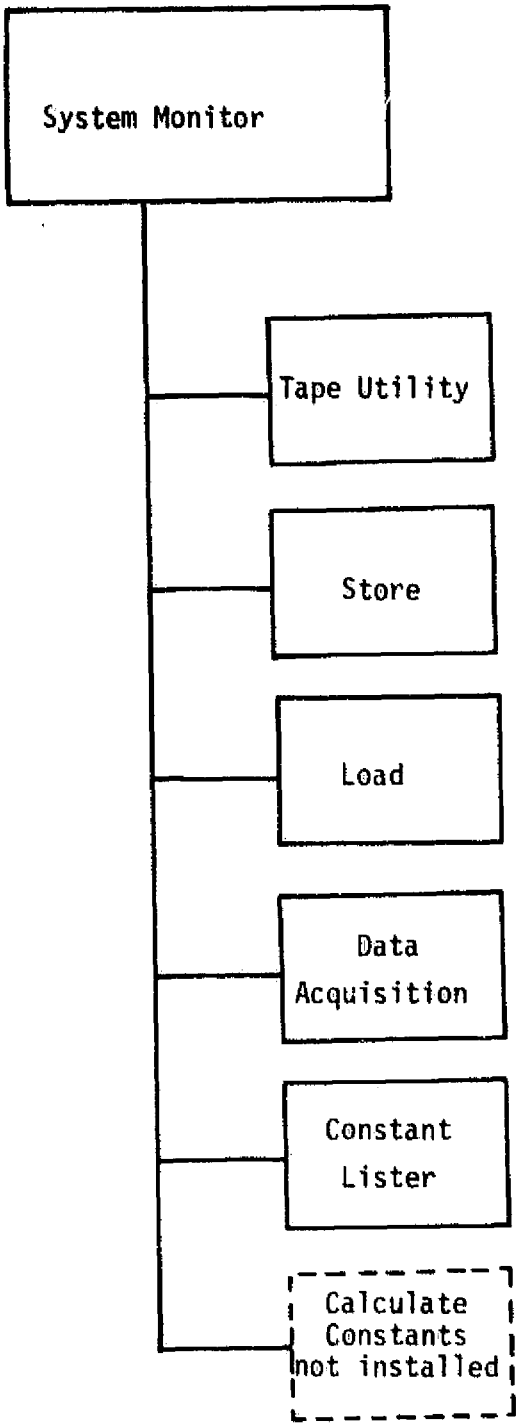

Figure 14. MSAS 8 Primary Logic Modules

Table 2.0 summarizes the command functions and responses for the SYSTEM MONITOR.

TAPE UTILITY Module Operations - The tape utility module has a four-command decoder, as indicated in Figure 15. Any command string entered on the teletype and not in the set will cause the message "*INVLD CMD " to be printed on the teletype. Table 3.0 summarizes the valid commands for TAPE UTILITY and that module's response. Table 4.0 summarizes error messages that may be generated when using TAPE UTILITY. Also presented is their probable cause/effect and any appropriate corrective actions.

STORE Module Execution - After the Operator has positioned the magnetic tape, put the unit ON LINE and invoked the STORE module, two decimal number entries are required from the Operator. These should be entered on the teletype when requested by the module. The first will be the starting address of the section of memory to be saved. Two conditions are imposed on this number.

a. The entry must be the decimal equivalent of the Octal address; e.g., $32_8 = 26_{10}$.

b. The entry must be greater than 11_{10} (= 13_8) because locations 10 and 11 (12_8 and 13_8) are used by the loader when mapping data back into memory.

After a valid starting address is received by the STORE module, it will request the ending or "LAST ADDR" of the section of memory to be stored on tape. Condition a., above, also applies to the second number entered. Further, the STAND-ALONE Loader and

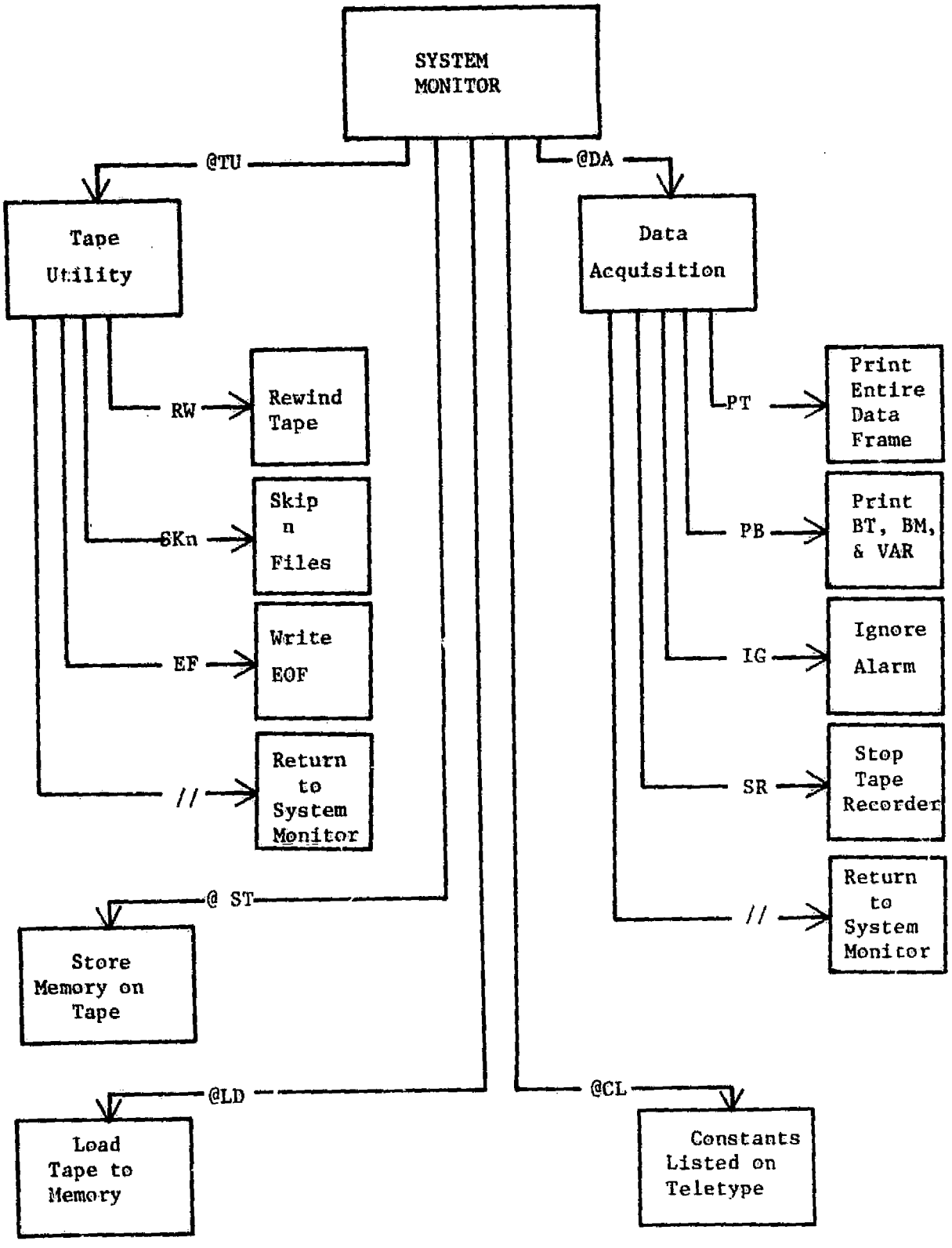

Figure 15. Over-all System Command Structure

Table 2.0

SYSTEM MONITOR Operations

COMMAND STRING	System Response is to transfer control to:
@TU	TAPE UTILITY
@ST	STORE
@LD	LOAD
@DA	DATA ACQUISITION
@CL	CONSTANT LISTER
@CC	CALCULATE CONSTANTS

ERROR MESSAGE	CAUSE OR INDICATION
CMD ERR	Invalid character string entered on the teletype
FALSE INTERRUPT	Invalid interrupt received while in SYSTEM MONITOR. Indicates interrupt mask is not set correctly or a hardware problem. Most likely cause is an incorrect -ystem start-up or loading procedure. Correct by re-loading the entire program from magnetic tape.

Table 3.0

TAPE UTILITY Routine Operations

COMMAND STRING	Response is control transfer to:	Sub-module Response:
RW	REWIND (tape)	Rewind the magnetic tape
SK	SKIP (file)	Skip n files on the magnetic tape
EF	Write EOF	Write an End-of-File mark on the magnetic tape
//	SYSTEM MONITOR	- - - - - - - - - - -

Table 4.0

TAPE UTILITY Error Messages

ERROR MESSAGE	CAUSE/INDICATION	CORRECTIVE ACTION
*NOT-RDY	Tape Unit not "ON LINE"	Press ON LINE switch on Tape Unit.
*EOT FOUND	End of Tape Encountered	Rewind/Replace magnetic tape
*LATE-RWDG	Last command is still being executed.	Re-enter command after tape unit finishes command currently being executed.
**BAD TAPE	Tape unit was unable to complete the command.	Unsually occurs if tape unit is taken off-line while executing a command.
**CMD IGND	Tape unit did not respond to the command issued.	Hardware problem likely to exist.
**INVLD CMD	Invalid command given by Operator while using the TAPE UTILITY	Re-call the routine and enter a valid command.
*LGNTH ERR	Number of bytes read does not match the number of bytes asked for; i.e., record length mismatch.	Tape record length errors indicate the wrong tape is being used, or a bad tape is being used, or a bad spot on the tape.
**WRITE-RNG	A write command was received, but the File protect switch was set.	Install a write-ring in the magnetic tape to be written on.
**ILLEG CMD	A Tape Unit command issued that was not in the command set.	Usually indicates a hardware problem or the software has become modified. Re-load the software.

Block Loader are protected by requiring that this number be less than 7829 (17225_8). After a satisfactory "LAST ADDR" is entered, the contents of the specified section of memory will be reformatted and written onto tape. A successful execution is signalled by the teletyped message "TAPE LOADED".

It is possible, during execution, for a tape unit malfunction or error to occur. The most likely three cases that can exist are:

a. *LATE RWDG

b. *BAD TAPE

c. *LNGTH ERR.

Error a. infers a hardware problem, Error b. will occur if the Tape Unit goes off-line, and Error c. will occur if there is a mismatch in the record length. Error c. will most likely be corrected by a higher quality tape; i.e., a tape with no bad spots.

LOAD Module Operation - The Load module is designed specifically to load files from magnetic tape which have been been placed on magnetic tape by the STORE module discussed above. It is not compatible with "standard" Nova object tape formats, since these tapes are generally punched paper and require a larger input buffer for execution.

The procedure for using this module is similar to STORE, except that no communication is required between the Operator and the software. The Operator need only mount the magnetic tape, position it to the correct file and place the

unit ON LINE. Next, the module is called by typing "@LD" on the teletype. The module first verifies that the tape file being loaded has "start" and "ending" addresses that are outside the MSAS-8 area of core; i.e., it will not allow over-writing of the area below approximately 5228 (= 12154_8). Successful execution is signalled by the teletype message "PROG LOADED". Table 5.0 summarizes the messages that may be displayed by the LOAD module.

CONSTANTS LISTER Module Utilization - When the command "@CL" is given while operating in the SYSTEM MONITOR module control is passed to the module which prints the contents of the three sets of Brightness Temperature calculation constants. There are no internal module communications required with the Operator. When invoked, the module causes the three constants tables to be listed on the teletype in the order that they are stored; i.e., L-band, C-band, and X-band. The entire printing takes several minutes. There are no error messages associated with this routine.

DATA ACQUISITION Module Operations - Figure 16-A and 16-B illustrate the logic sequence and communications between the software system and the Operator during execution of the Data Acquisition Module. Following the logic from the entry point, the software will ascertain (Block 1.0) if a shut-down occurred due to power failure and if so it will print the "POWER FAILURE" message. If the "Power-turn-off" procedure discussed earlier in this section is used the "POWER FAILURE" message will always be displayed upon first entry into this routine after a power turn-off.

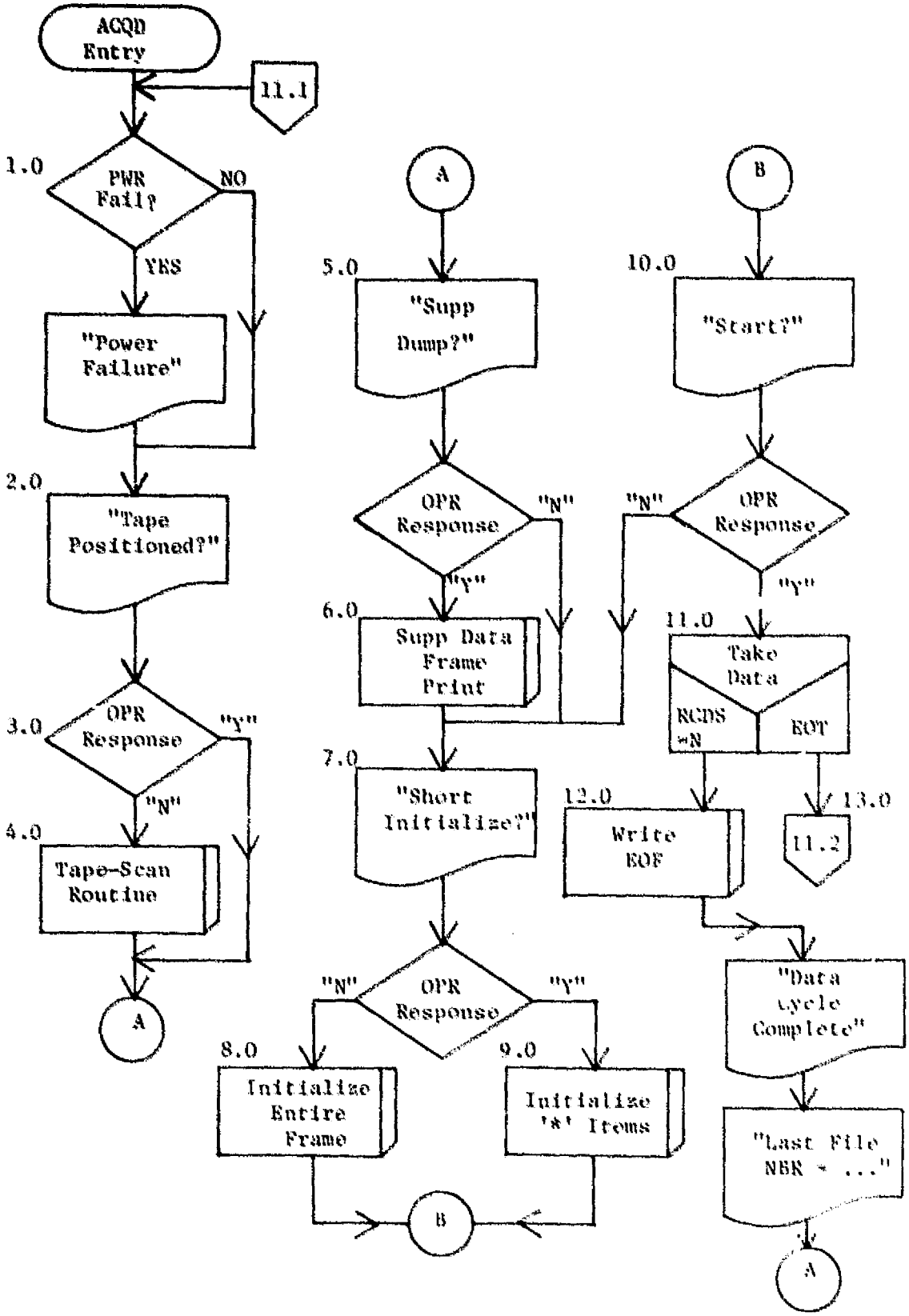

Figure 16-A. MSAS 8 Data Acquisition Module Communications

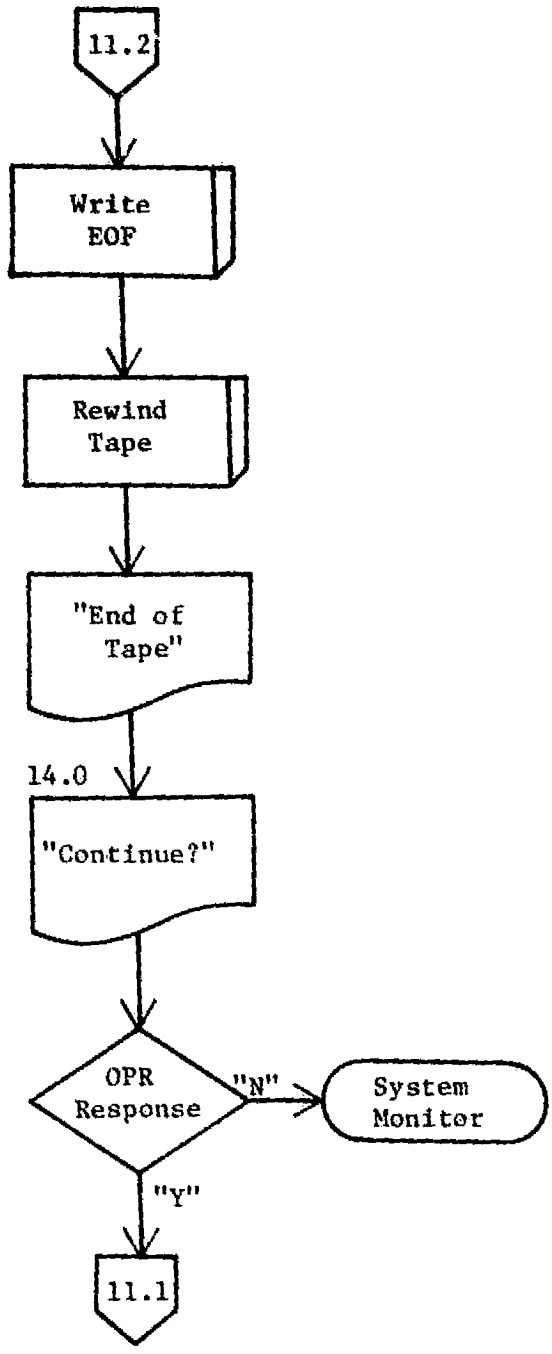

Figure 16-B. MSAS 8 Data Acquisition Module Communications

Table 5.0

LOAD Module Message

Message	Cause	Operator Action
PROG LOADED	Correction Execution	
*LOAD ERR	Address field inside of MSAS 8 module	Tape cannot be loaded with this module. May be allowed by S/A LOADER.
*EOF BEFORE EOL	An End-of-File was encountered before the end of the load module	Indicates an erroneous tape file.

At Block 2.0 in Figure 16-A the System is establishing that the magnetic tape is mounted and ready to accept data. If the Operator's response, Block 3.0, is "N" the TAPE-SCAN routine, (Block 4.0) is executed. This routine asks the Operator for the "LAST FILE NBR?". The routine then attempts to position the tape at the first file past the number entered by the Operator; e.g., a response of zero will cause the next data to be written on File 1.

Next, the Operator is asked if a Supplementary Frame print-out ("SUPP DUMP?"), Block 5.0, is desired. If the response is "Y" the present contents of the Supplementary Data values will be printed on the teletype. Figure 17.0 shows a sample of this print out.

As indicated in Block 7.0 of Figure 16-A the next decision point for the Operator is the type of Initialization to make. An "N" response to the "SHORT INITIALIZE?" message will cause all the items in Figure 18.0 to be reinitialized. The software will ask, via teletype, for each item in the order shown. The System expects no more than 4 decimal digits for each of the first three items. The Date and Time entries must have a "/" (slash) separating each of the three pairs of entries; e.g., Jan. 1, 1978 is entered as 01/01/78 while 4:31:27 PM is entered as 04/31/27. The next item, "FRAMES PER B-TMP MEAN:" determines how many frames (each with one value of brightness temperature)

```
SUPP DUMP?Y

 TAPE NBR:   00001
 FILE NBR:   00001
 FIELD NBR: 00001
 DATE: 06   21   78
 TIME: 02   14   41
 FRAMES PER B-TMP MEAN: 00030
 NBR TAPE RCDS: 00100
 ANGLE: 00045
 POLARIZ: V
```

ORIGINAL PAGE IS
OF POOR QUALITY

Figure 17. Sample Print Out of Supplementary Frame

ORIGINAL PAGE IS
OF POOR QUALITY

TAPE NBR: _ _ _ _

FILE NBR: _ _ _ _

FIELD NBR: _ _ _ _

DATE: _ _/ _ _ / _ _

TIME: _ _/ _ _ / _ _

FRAMES PER B-TMP MEAN: _ _ _ _ (≥ 16)

NO. TAPE RCDS/CYCLE: _ _ _ _

*FREQ/BAND SEL'D? _

*ANGLE: _ _ _ _

*POLARIZ: _ ('H' or 'V')

*SUPP:

Figure 18.0 INITIALIZATION Data Frame

will be used in computing the brightness temperature mean value. This value must be greater than 15. The "NO.TAPE RCDS/CYCLE" sets the number of data frame pairs (Type I and Type II sets [5]) that will be written on magnetic tape during the next data taking cycle. The message "FREQ/BAND SEL'D?" causes no data initialization, but is simply a reminder to the Operator to select the desired frequency on the Front Panel. A "Y" response by the Operator will cause the next item, ANGLE, to be initialized. Up to three decimal digits may be entered. No checking for reasonable values is done. After the "ANGLE" value is entered the System will expect the polarization to be entered as a "V" or "H" character. The final entry for a "long" Initialize is the supplementary ("SUPP") comments. The System will accept up to 96 characters in two equal length lines.

Referring back to Figure 16-A, if following Block 7.0 the Operator responds with "Y" then the "short" Initialization (Block 9.0) will be executed. In this routine only those items in Figure 18.0 which are preceded by an "*" will be requested by the Operator.

Following entry of the supplementary comments, the System is ready to begin taking data. This is signified by the "START?" message. At this point the Operator can return to the "SHORT INITIALIZE" (Block 7.0) or proceed to take data. There is a third option that is available at any "OPR RESPONSE" decision point, such as Block 3.0, and that is to type an "ESC" character on the teletype. This option transfers control,

unconditionally, back to the SYSTEM MONITOR module. Normally, however, the response following Block 10.0 is a "Y" and control is passed to the "data-taking" module, Block 11.0. Control remains in this module until the number of records ("NO. TAPE RCDS/CYCLE") requested has been written on magnetic tape. Alternatively, if an End-of-Tape (EOT) encounter occurs on the tape unit, control will pass to Block 13.0 where an End-of-File is automatically written and a tape rewind is executed. As indicated in Figure 16-B, the Operator is then given the option of continuing with another data acquisition cycle or returning control to the SYSTEM MONITOR. Table 6.0 summarizes all messages expected during normal, sequential operation of the DATA ACQUISITION module. Error messages which may occur during operations in this module include those associated with the TAPE UTILITY module, Table 4.0.

MSAS Controller Shut Down Procedure

1. Return program to SYSMO.
2. Make sure Rolm key is in LOCK position.
3. Turn tape deck off.
4. Turn off system controller.

The above procedure will ensure proper restarts when the system is turned back on.

Antenna Positioner and Accessory Shut Down

1. Switch manual antenna positioner box on boom truck to the "Manual" position.

2. Take truss off boom truck and store in data van.

3. Turn off voltage regulator.

4. Turn off air conditioner and other accessories. (The light switch may be left on so that when main disconnect is turned on the next time, the light will come on.)

5. Turn off main disconnect.

6. Stop generator engine.

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[2] B. V. Clark and R. W. Newton, "Microwave Signature Acquisition System Software Operating System and Procedures," Report RSC 3308-2, Remote Sensing Center, Texas A&M University, May 1978.

[3] B. R. Jean, D. W. Presley, G. L. Warren, R. W. Newton, and J. P. Claassen, "Microwave Signature Acquisition System C-Band Channel Maintenance Manual," Report RSC 3308-3, Remote Sensing Center, Texas A&M University, May 1978.

[4] B. R. Jean, R. O. Stroud, R. Q. Black, G. L. Warren, and R. W. Newton, "Microwave Signature Acquisition System Antenna Positioner Maintenance Manual," Report RSC 3308-4, Remote Sensing Center, Texas A&M University, May 1978.

[5] B. R. Jean, R. W. Newton, G. L. Warren, B. V. Clark, and J. L. Zajicek, "Improvements and Modifications to the NASA Microwave Signature Acquisition System," Report RSC 3308-5, Remote Sensing Center, Texas A&M University, May 1978.

[6] B. V. Clark and R. W. Newton, "Revision to Operating System Software for Microwave Signature Acquisition System (MSAS)," Technical Report RSC-75, Remote Sensing Center, Texas A&M University, July 1976.

Table 6.0

DATA ACQUISITION Module Messages

Message	Operator Response	SYSTEM/MODULE RESPONSE
"PWR FAILURE"	none	none; CPU sensed power-off or loss
"TAPE POSITIONED?"	'Y'	By passes tape positioning module (TAPE-SCAN).
	'N'	·Executes tape positioning module
"LAST FILE NBR:"	n(≤9999)	Skips n files on tape unit.
"SUPP DUMP?"	'Y'	Prints present contents of Initialization Data Values.
	'N'	By-passes Initialization Data Value print out.
"SHORT INITIALIZE"	'Y'	Allows changing only '*'-items of Initialization Data.
	'N'	Allows changing all items of Initialization Data.
"TAPE NBR:"	n(≤9999)	Saves Tape Identification for use in output data.
"FILE NBR:"	n(≤9999)	Sets initial value of File Counter
"FIELD NBR:"	n(≤9999)	Saves Field Identifier for use in output data.
"DATE:"	mm/dd/yy	Saves Date Identifier for use in output data.
"TIME:"	hh/mm/ss	Sets and starts program clock for use in output data.
"FRAMES PER B-TMP MEAN"	n(≤9999)	Sets Frame Counter to trigger calculation of Brightness Temperature mean and variance normally ≥16 and ≤100.

Table 6.0 (cont'd)

Message	Operator Response	SYSTEM/MODULE RESPONSE
"NBR TAPE RCDS:"	n(≤9999)	Sets counter to signal end of Tape File
"BAND SEL'D?"	'Y'	Continues execution
	'N'	Prints "THEN DO IT ---"
"ANGLE:"	n(≤9999)	Saves angle value for output data frame
"POLARIZE:"	"H" or "V"	Saves Polarization character for output data
"SUPP:"	Type up to 96 characters of supplemental data for tape record	Stores 96 characters of supplemental comments along with Initialization data in one tape record at the beginning of the file.
"COMPL"	none	Signifies completion of the supplemental data entry.
"START?"	'Y'	Begins data acquisition and recording
	'N'	Recycles to "SHORT INITIALIZE?" query.
"CYCLE END, LAST FILE"	none	Signifies completion of recording the requested number of tape records. Gives File number of File just completed.
"END OF TAPE"	Load a new data tape	An end-of-tape (EOT) was found during recording of the requested data set.
"CONTINUE?"	'Y'	Re-cycle control to entry of the DATA ACQUISITION module.
	'N'	Re-cycle control to the entry of the SYSTEM MONITOR module.
"ALARM ERROR"	Check radiometer hardware for malfunction	Signifies any of the following: Band Over or Under Range bit is set; 28 Volt-reading error; L-, C-, or X-band Monitor Alarm bit is set.

Table 6.0 (cont'd)

Message	Operator Response	SYSTEM/MODULE RESPONSE
"PARITY ERR"	Check radiometer hardware for a malfunction	Data frame, 32 words, has erroneous parity count, i.e., parity count is not even.
"TEST WORD ERR"	Check radiometer hardware for a malfunction	Test word Nbr. 29 or the 32 Word data frame is in error; i.e., all bits are not set correctly.
"FALSE INTERRU"	Possible hardware or software error	System has received an interrupt that is not in the allowable structure.